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IS 14901-5-1 (2010): Semiconductor Devices - Discrete Devices and Integrated Circuits, Part 5: Optoelectronic Devices, Section 1: General [LITD 5: Semiconductor and Other Electronic Components and Devices]



“ज्ञान से एक नये भारत का निर्माण”

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“ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है”

Bhartrhari—Nitiśatakam

“Knowledge is such a treasure which cannot be stolen”

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IS 14901 (Part 5/Sec 1):2010
IEC 60747-5-1 : 2002

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अनुभाग 1 सामान्य
(पहला पुनरीक्षण)

Indian Standard
SEMICONDUCTOR DEVICES — DISCRETE
DEVICES AND INTEGRATED CIRCUITS
PART 5 OPTOELECTRONIC DEVICES
Section 1 General
(*First Revision*)

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NATIONAL FOREWORD

This Indian Standard (Part 5/Sec 1) (First Revision) which is identical with IEC 60747-5-1 : 2002 ‘Discrete semiconductor devices and integrated circuits — Part 5-1: Optoelectronic devices — General’ issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on the recommendation of the Semiconductor and Other Electronic Components and Devices Sectional Committee and approval of the Electronics and Information Technology Division Council.

This standard was originally published in 2004 and was based on IEC 60747-5 : 1992 and has now been revised to align it with the latest IEC Publication.

The text of the IEC Standard has been approved as suitable for publication as an Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

- a) .Wherever the words ‘International Standard’ appear referring to this standard, they should be read as ‘Indian Standard’.
- b) Comma (,) has been used as a decimal marker in the International Standard while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

The technical committee has reviewed the provisions of following International Standards referred in this adopted standard and has decided that they are acceptable for use in conjunction with this standard:

<i>International Standard</i>	<i>Title</i>
IEC 60050 (731) : 1991	International Electrotechnical Vocabulary (IEV) — Chapter 731 : Optical fibre communication
IEC 60050 (845) : 1987	International Electrotechnical Vocabulary (IEV) — Chapter 845 : Lighting
IEC 60664-1 : 1992	Insulation coordination for equipment within low-voltage systems — Part 1: Principles, requirements and tests

Indian Standard

**SEMICONDUCTOR DEVICES — DISCRETE
DEVICES AND INTEGRATED CIRCUITS**

PART 5 OPTOELECTRONIC DEVICES

Section 1 General

(First Revision)

1 Scope

This part of IEC 60747 deals with the terminology relating to the semiconductor optoelectronic devices.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050(731), 1991, *International Electrotechnical Vocabulary (IEV) – Chapter 731: Optical fibre communication*

IEC 60050(845):1987, *International Electrotechnical Vocabulary (IEV) – Chapter 845: Lighting*

IEC 60664-1:1992, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

3 Physical concepts

3.1 (Electromagnetic) radiation (IEV 845-01-01)

- 1) Emission or transfer of energy in the form of electromagnetic waves with the associated photons.
- 2) These electromagnetic waves or these photons.

3.2 Optical radiation (IEV 845-01-02)

Electromagnetic radiation of wavelengths lying between the region of transition to X-rays (≈ 1 nm) and the region of transition to radio waves (≈ 1 nm).

3.3 Visible radiation (IEV 845-01-03)

Any optical radiation capable of causing a visual sensation directly.

NOTE There are no precise limits for the spectral range of visible radiation since they depend upon the amount of radiant power available and the responsivity of the observer. The lower limit is generally taken between 360 nm and 400 nm and the upper limit between 760 nm and 830 nm.

3.4 Infrared radiation (IEV 845-01-04, specialized)

Optical radiation for which the wavelengths are longer than those for visible radiation.

3.5 Ultraviolet radiation (IEV 845-01-05, specialized)

Optical radiation for which the wavelengths are shorter than those for visible radiation.

3.6 Light (IEV 845-01-06, without note 2 which is not relevant)

3.6.1 Perceived light (see IEC 845-02-17)

3.6.2 Visible radiation (see IEC 845-01-03)

NOTE Concept 2 is sometimes used for optical radiation extending outside the visible range, but this usage is not recommended.

3.7 Photoelectric effect (from IEC 845-05-33: photoelectric detector)

Interaction between optical radiation and matter resulting in the absorption of photons and the consequent generation of mobile charge carriers, thereby generating an electric potential or current, or a change in electrical resistance, excluding electrical phenomena caused by temperature changes.

4 Types of devices

4.1 Semiconductor optoelectronic device

- 1) A semiconductor device that emits or detects or that is responsive to coherent or non-coherent optical radiation.
- 2) A semiconductor device that utilizes such radiation for its internal purposes.

4.2 Semiconductor photoemitter

A semiconductor optoelectronic device that directly converts electric energy into optical radiant energy.

4.3 Semiconductor laser

4.3.1 (Semiconductor) laser diode

A semiconductor diode that emits coherent optical radiation through stimulated emission resulting from the recombination of free electrons and holes when excited by an electric current that exceeds the threshold current of the diode.

NOTE The laser diode is mounted on a submount or in a package with or without coupling means (e.g. lens, pigtail).

4.3.2 Laser-diode module

A module containing, together with the laser diode, means for an automatic optical and/or thermal stabilization of the radiant output power.

4.4 Light-emitting diode (LED)

A semiconductor diode, other than a semiconductor laser, capable of emitting visible radiation when excited by an electric current.

4.5 Infrared-emitting diode (IRED)

A semiconductor diode other than a semiconductor laser capable of emitting infrared radiation when excited by an electric current.

4.6 (Semiconductor) photosensitive device

A semiconductor device that utilizes the photoelectric effect for detection of optical radiation.

4.7 (Semiconductor) photoelectric detector

A semiconductor device that utilizes the photoelectric effect for detection of optical radiation.

4.8 (Semiconductor) photoresistor, photoconductive cell (IEV 845-05-37, specialized)

A semiconductor photoelectric detector that utilizes the change of electric conductivity produced by the absorption of optical radiation.

4.9 Photoelement, photovoltaic cell (IEV 845-05-38)

A photoelectric detector that utilizes the electromotive force produced by the absorption of optical radiation.

4.10 Photodiode (IEV 845-05-39)

A photoelectric detector in which a photocurrent is generated by absorption of optical radiation in the neighbourhood of a PN junction between the semiconductors, or of a junction between a semiconductor and a metal.

4.11 Phototransistor

A transistor in which the current produced by the photoelectric effect in the neighbourhood of the emitter-base junction acts as base current, which is amplified.

4.12 Photothyristor

A thyristor that is designed to be triggered by optical radiation.

4.13 Photocoupler, optocoupler

A semiconductor optoelectronic device designed for the transfer of electrical signals by utilizing optical radiation to provide coupling with electrical isolation between the input and the output.

4.13.1 DC input photocoupler/optocoupler

Photocoupler/optocoupler consisting at the input of an optoelectronic emitter to which d.c. current is applied

4.13.2 AC input photocoupler/optocoupler

Photocoupler/optocoupler consisting at the input of an antiparallel optoelectronic emitter to which a.c. current is applied

4.13.3 Phototransistor photocoupler/optocoupler

Photocoupler/optocoupler whose photosensitive element is a phototransistor

NOTE A base terminal may or may not be provided.

4.13.4 Photodarlington photocoupler/optocoupler

Photocoupler/optocoupler whose photosensitive element is a Darlington phototransistor

NOTE A base terminal may or may not be provided.

4.13.5 Photothyristor photocoupler/optocoupler

Photocoupler/optocoupler whose photosensitive element is a photothyristor

NOTE A gate terminal may or may not be provided.

4.13.6 Phototriac photocoupler/optocoupler

Photocoupler/optocoupler whose photosensitive element is a phototriac

4.13.7 IC photocoupler/optocoupler

Photocoupler/optocoupler whose photosensitive element is a photodiode/phototransistor and an integrated circuit

4.13.8 FET photocoupler/optocoupler

Photocoupler/optocoupler with one or more field-effect transistors (FETs) in its output stage

NOTE A FET is activated by photo-elements or by direct optical radiation.

4.13.9 Photodiode photocoupler/optocoupler

Photocoupler/optocoupler whose photosensitive element is a photodiode

4.13.10 IC input photocoupler/optocoupler

photocoupler/optocoupler whose input elements consist of an integrated circuit and an optoelectronic emitter

5 General terms

5.1 Optical axis

A line about which the principal radiation or sensitivity pattern is centered.

NOTE Unless otherwise stated, the optical axis coincides with the direction of maximum radiation or sensitivity.

5.2 Optical port (of a semiconductor optoelectronic device)

A geometrical configuration, referenced to an external plane or surface of the device, that is used to specify the optical radiation emitted from an emitting device or accepted by a detecting device.

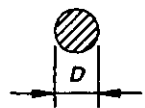
NOTE The geometrical configuration shall be specified by the manufacturer by means of geometrical information, e.g.:

- location, shape and size of the area of emission or acceptance,
- angle of emission or acceptance,
- other parameters, e.g. numerical aperture of optical fibre,
- orientation of optical axis.

Examples:

Signification of annotations in the figures:

α = emission or acceptance angle

 = optical port with diameter D

Ref. = reference locus for the definition of the optical port.

Example 1: *Devices with pigtail (emitter or detector)*

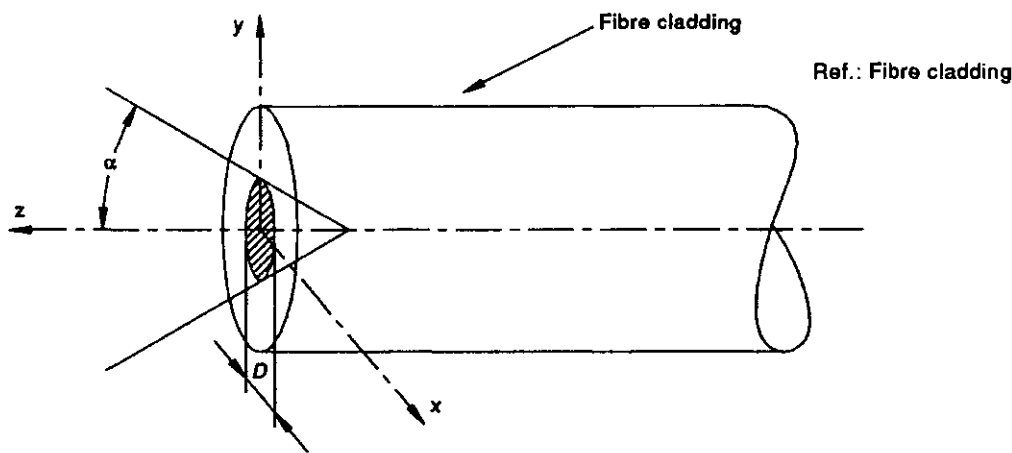


Figure 1a – Device with bare fibre pigtail

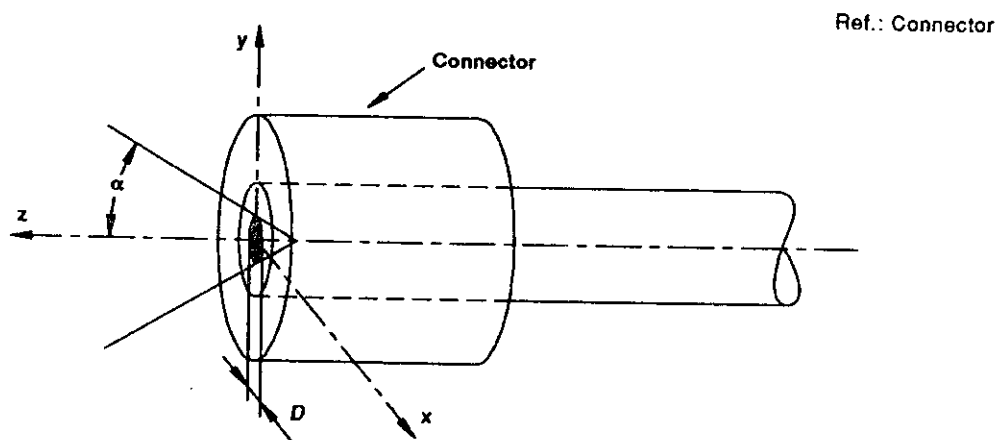


Figure 1b – Device with fibre pigtail connector attached

Example II: *Packaged devices (emitter or detector), without pigtail*

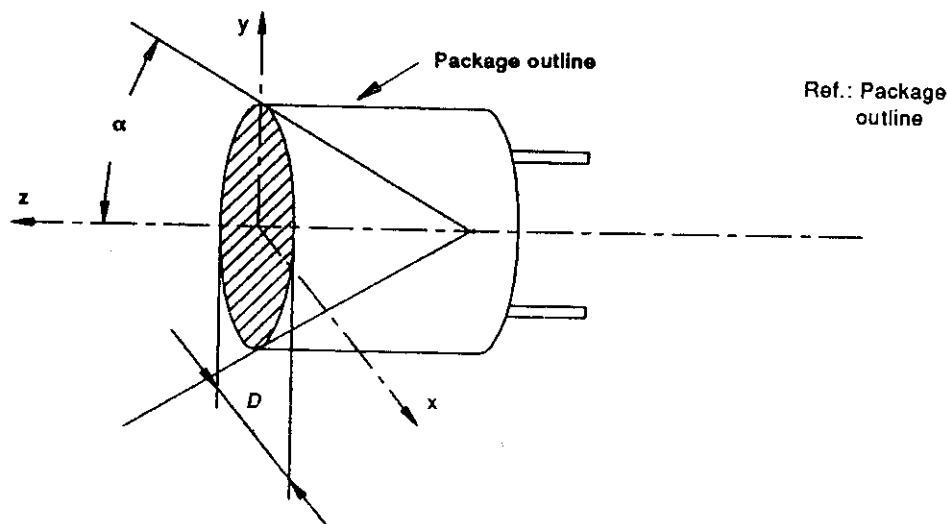


Figure 2a – Device with window, but without lens

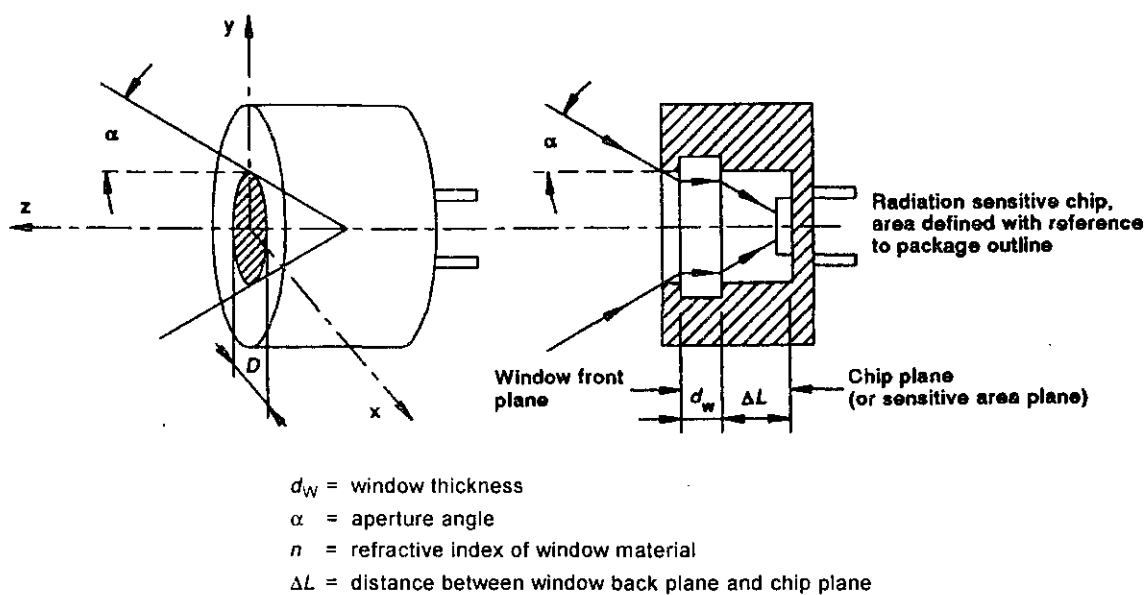


Figure 2b – Detector with window, but without lens (chip referenced)

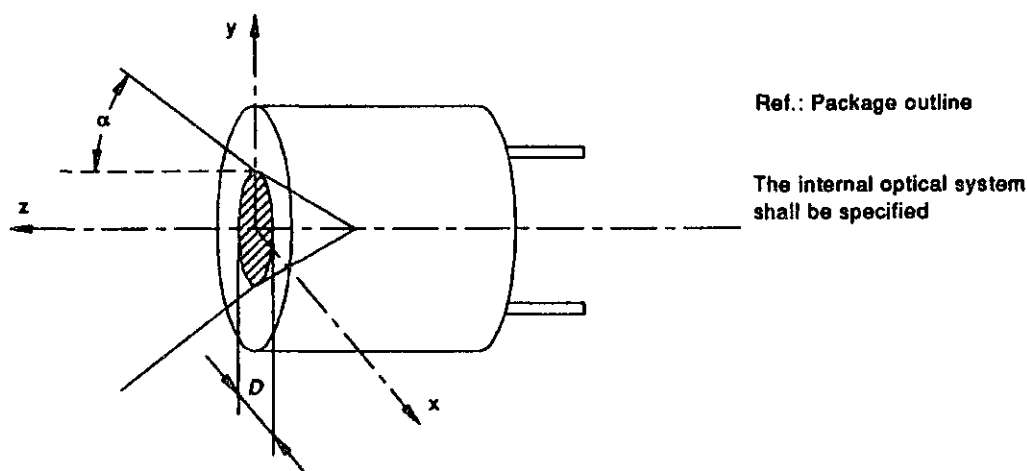


Figure 2c – Detector with lens

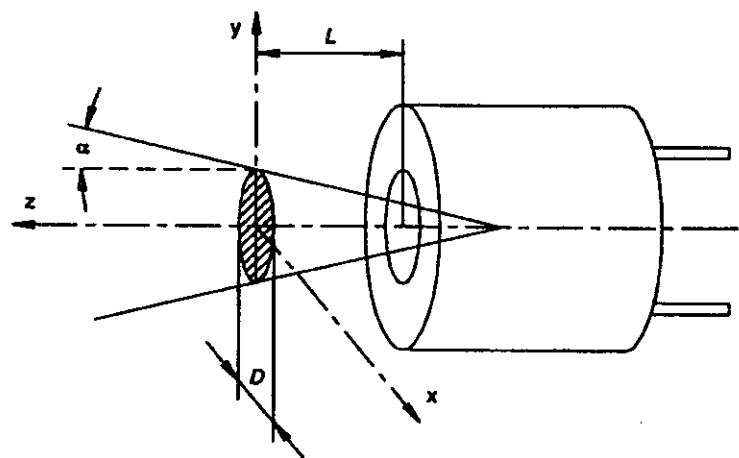


Figure 2d – IRED with optical port that is not located on the output window of the package

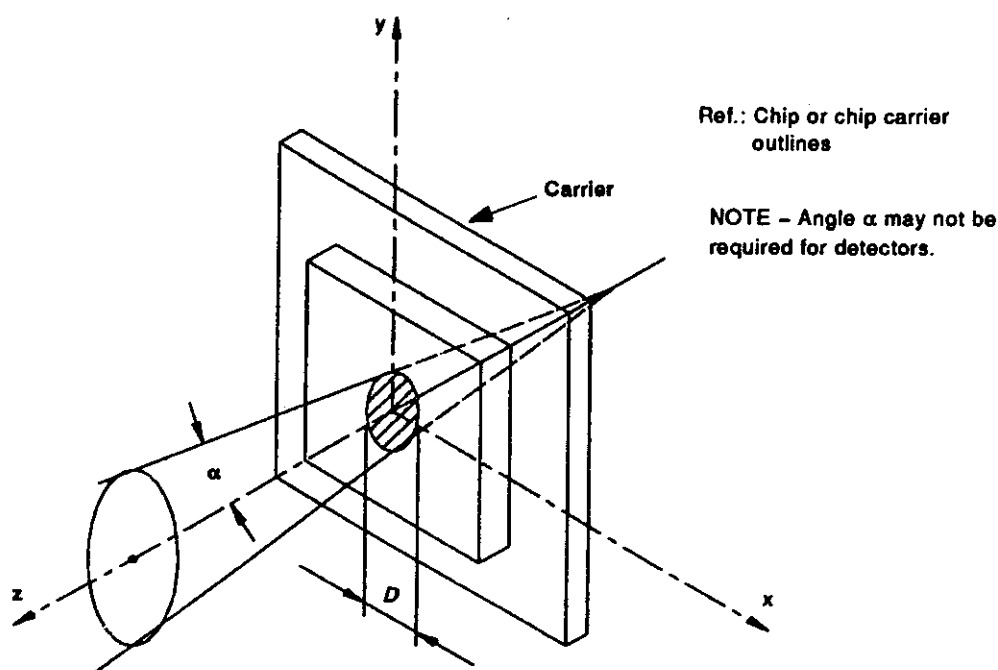


Figure 3 – Non-packaged devices (emitter or detector) without pigtail

5.3 (Optical) cladding (IEV 731-02-05)

That dielectric material of an optical fibre surrounding the core.

6 Terms related to ratings and characteristics

6.1 General

6.1.1 Switching times

NOTE The specified lower and upper limit values referred to in concepts 6.1.1.1 to 6.1.1.6 are usually 10 % and 90 % of the amplitude of the pulses (see figure 4).

6.1.1.1 Turn-on delay time $t_{d(on)}$

The time interval between the lower specified value on the leading edge of the applied input pulse and the lower specified value on the leading edge of the output pulse.

6.1.1.2 Rise time t_r

The time interval between the lower specified value and the upper specified value on the leading edge of the output pulse.

6.1.1.3 Turn-on time t_{on}

The time interval between the lower specified value on the leading edge of the applied input pulse and the upper specified value on the leading edge of the output pulse.

$$t_{on} = t_{d(on)} + t_r$$

6.1.1.4 Turn-off delay time $t_{d(off)}$

The time interval between the upper specified value on the trailing edge of the applied input pulse and the upper specified value on the trailing edge of the output pulse.

NOTE If the turn-off delay time is mainly due to carrier storage (e.g. in the output transistor of a photocoupler), the term "(carrier) storage time" and the letter symbol t_s are in use.

6.1.1.5 Fall time t_f

The time interval between the upper specified value and the lower specified value on the trailing edge of the output pulse.

6.1.1.6 Turn-off time t_{off}

The time interval between the upper specified value on the trailing edge of the applied input pulse and the lower specified value on the trailing edge of the output pulse.

$$t_{off} = t_{d(off)} + t_f$$

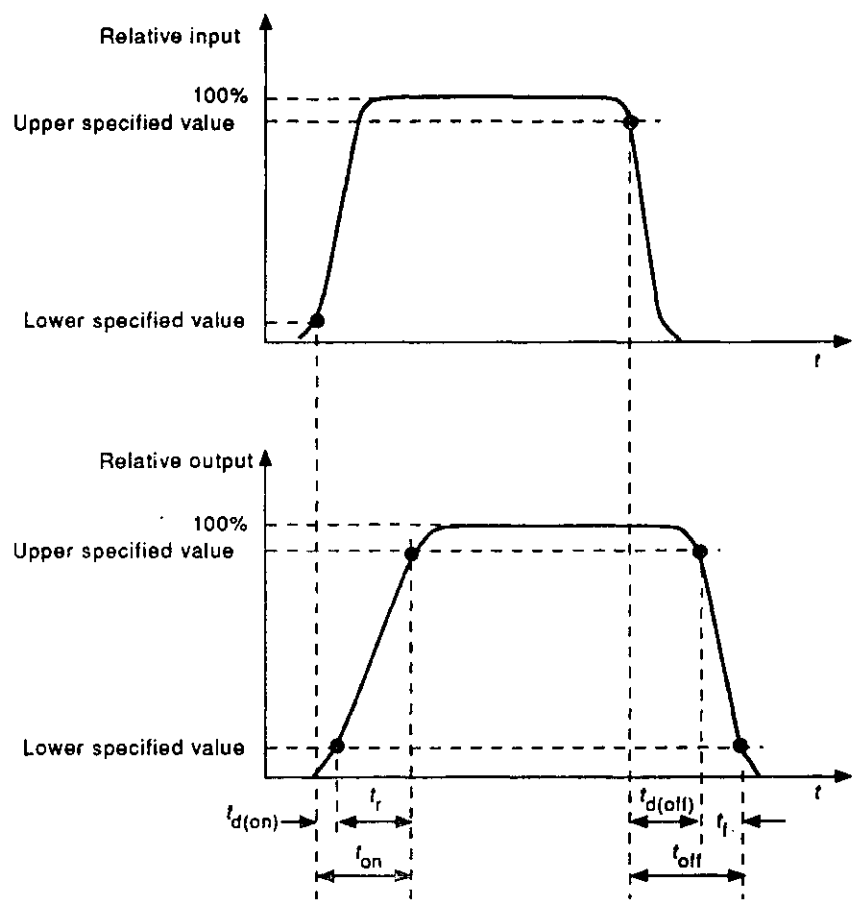


Figure 4 – Switching times

6.2 Photoemitters

6.2.1 Radiant power, luminous flux

6.2.1.1 Radiant power (of a photoemitter) ϕ_e

The radiant power emitted from the optical port of the device.

6.2.1.2 Luminous flux (of a photoemitter) ϕ_v

The luminous flux emitted from the optical port of the device.

6.2.2 Efficacies

6.2.2.1 Radiant power efficacy η_e , η radiant efficacy
(of an infrared-emitting diode or a laser diode)

The quotient of the emitted radiant power ϕ_e , by the forward current I_F :

$$\eta_e = \phi_e / I_F$$

NOTE If no ambiguity is likely to occur, particularly with the term IEC 845-01-54: "radiant efficiency" $\eta_e = \phi_e / (I_F \cdot V_F)$, the term may be shortened to "radiant efficacy" or "efficacy". This is nearly always possible.

6.2.2.2 Radiant intensity efficacy η_{ei} (of an infrared-emitting diode or a laser diode)

The quotient of the emitted radiant intensity I_e , by the forward current I_F :

$$\eta_{ei} = I_e / I_F$$

6.2.2.3 Luminous flux efficacy η_v luminous efficacy (of a light-emitting diode)

The quotient of the emitted luminous flux ϕ_v , by the forward current I_F :

$$\eta_v = \phi_v / I_F$$

NOTE If no ambiguity is likely to occur, particularly with the terms IEC 845-01-55: "luminous efficacy of a source" $\eta_v = \phi_v / (I_F \cdot V_F)$, or IEC 845-01-56: "luminous efficacy of a radiation" $K = \phi_v / \phi_e$, the term may be shortened to "luminous efficacy" or "efficacy". This is nearly always possible.

6.2.2.4 Luminous intensity efficacy η_{vi} (of a light-emitting diode)

The quotient of the emitted luminous intensity I_v , by the forward current I_F :

$$\eta_{vi} = I_v / I_F$$

6.2.2.5 Differential radiant power efficacy η_{ed} , η_d differential radiant efficacy (of an infrared-emitting diode or a laser diode)

The radiant power efficacy for small-signal modulation:

$$\eta_{ed} = d\phi_e / dI_F$$

NOTE 1 If no ambiguity is likely to occur, the shorter term and letter symbol may be used.

NOTE 2 The term "small-signal modulation efficacy" is in use as synonym.

6.2.2.6 Differential radiant intensity efficacy η_{eid} (of an infrared-emitted diode or a laser diode)

The radiant intensity efficacy for small-signal modulation:

$$\eta_{eid} = dI_v / dI_F$$

6.2.2.7 Differential luminous flux efficacy η_{vd} , η_d differential luminous efficacy (of a light-emitting diode)

The luminous flux efficacy for small-signal modulation:

$$\eta_{vd} = d\phi_v / dI_F$$

NOTE 1 If no ambiguity is likely to occur, the shorter term and letter symbol may be used.

NOTE 2 The term "small-signal modulation efficacy" is in use as synonym.

6.2.2.8 Differential luminous intensity efficacy η_{vid} (of a light-emitting diode)

The luminous intensity efficacy for small-signal modulation:

$$\eta_{vid} = dI_v / dI_F$$

6.2.2.9 Large-signal radiant power efficacy η_{EL} , η_L large-signal radiant efficacy (of an infrared-emitting diode or a laser diode)

The radiant power efficacy for large-signal modulation:

$$\eta_{EL} = \Delta\phi_e / \Delta I_F$$

NOTE If no ambiguity is likely to occur, the shorter term and letter symbol may be used.

6.2.2.10 Large-signal radiant intensity efficacy η_{EIL} (of an infrared-emitting diode or a laser diode)

The radiant intensity efficacy for large-signal modulation:

$$\eta_{EIL} = \Delta I_e / \Delta I_F$$

6.2.2.11 Large-signal luminous flux efficacy η_{VL} , η_L large-signal luminous efficacy (of a light-emitting diode)

The luminous flux efficacy for large-signal modulation:

$$\eta_{VL} = \Delta\phi_v / \Delta I_F$$

NOTE If no ambiguity is likely to occur, the shorter term and letter symbol may be used.

6.2.2.12 Large-signal luminous intensity efficacy η_{VIL} (of a light-emitting diode)

The luminous intensity efficacy for large-signal modulation:

$$\eta_{VIL} = \Delta I_v / \Delta I_F$$

6.2.3 Cut-off frequency

6.2.3.1 Small-signal (modulation) cut-off frequency f_{cd} , f_c (of a photoemitting diode)

The frequency at which, for constant modulation depth of the forward current, the demodulated a.c. optical radiant power has decreased to 1/2 of its low-frequency value.

6.2.3.2 Large-signal (modulation) cut-off frequency f_{CL} , F_c (of a photoemitting diode)

Under consideration.

6.2.4 Threshold current (of a laser diode) $I_{(TH)}$

The forward current at which the second derivative of the curve showing radiant power ϕ_e versus forward current I_F has its first maximum (see figure 5).

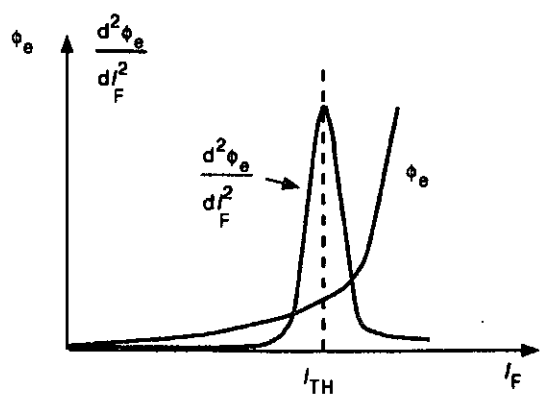


Figure 5 – Threshold current of a laser diode

6.2.5 Spatial radiation diagram and related characteristics (of a photoemitter)

6.2.5.1 Radiation diagram

A diagram that characterizes the distribution of radiant (or luminous) intensity:

$$I_e \text{ (or } I_v) = f(\theta) \text{ (see figures 6a and 6b)}$$

NOTE 1 Unless otherwise stated, the distribution of the radiant (or luminous) intensity should be specified in a plane. This plane includes the mechanical axis z.

NOTE 2 If the radiation pattern has a rotational symmetry of the z axis, the radiation diagram shall be specified for one plane only.

NOTE 3 If the radiation pattern has no rotational symmetry to the z axis, radiation diagrams for various angles ϕ shall be specified. Then the x, y and z directions shall be defined by a drawing in the detail specification.

6.2.5.2 Half-intensity angle $\theta_{1/2}$

In a radiation diagram, the angle within which the radiant (or luminous) intensity is greater than or equal to half of the maximum intensity (see figure 6b).

6.2.5.3 Misalignment angle $\Delta\theta$

In a radiation diagram, the angle between the direction for maximum radiant (or luminous) intensity (optical axis) and the mechanical axis z (see figure 6b).

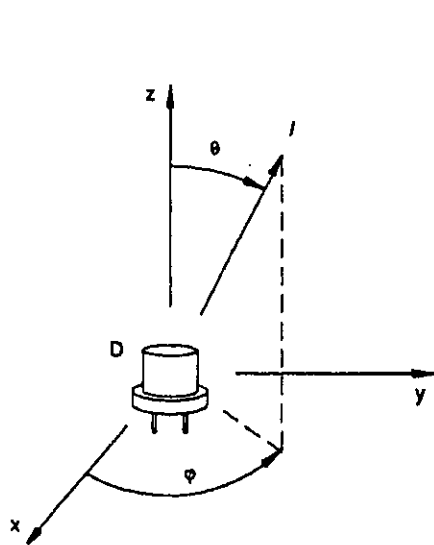


Figure 6a

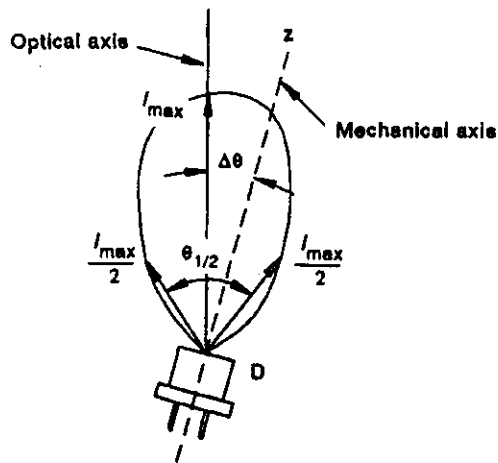


Figure 6b

Figure 6 – Radiation diagram and related characteristics

6.2.6 Spectral characteristics (of light-emitting diodes and infrared-emitting diodes)
(see figure 7)

6.2.6.1 Peak-emission wavelength λ_p

The wavelength at which the spectral radiant power is a maximum.

6.2.6.2 Spectrum bandwidth $\Delta\lambda$

The wavelength interval in which the spectral radiant power is greater or equal to half of its maximum value.

6.2.6.3 (Relative) parasitic radiant power $\phi_{e(par)}$ or luminous flux $\phi_{v(par)}$

The value of undesired spectral radiant power (or luminous flux) in two specified wavelength ranges that lie below and above the peak-emission wavelength, expressed as a percentage of the radiant power (or luminous flux) at peak-emission wavelength.

NOTE Specified values refer to the maximum value within each of the specified wavelength ranges.

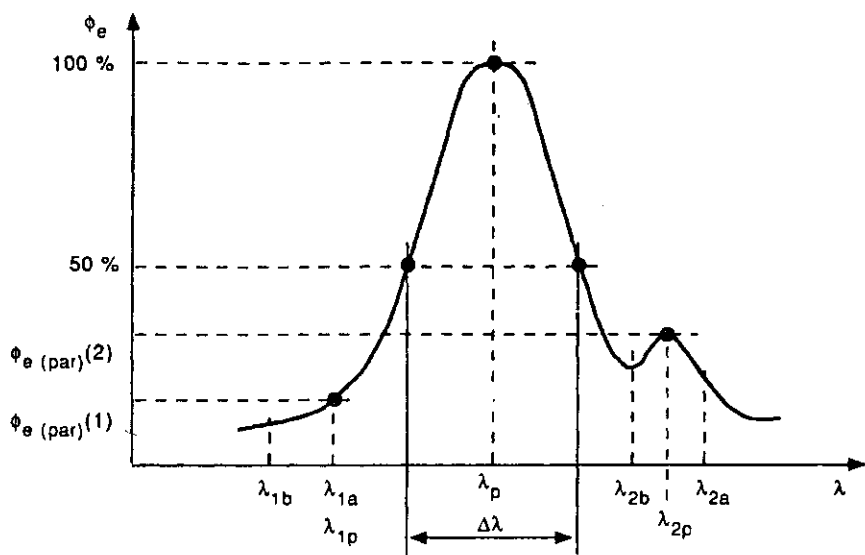


Figure 7 – Spectral characteristics of light-emitting diodes and infrared-emitting diodes

6.2.7 Spectral characteristics (of laser diodes and laser-diode modules) (see figure 8)

6.2.7.1 Peak-emission wavelength λ_p

The wavelength at the peak value of the mode with the maximum spectral radiant power.

6.2.7.2 Spectrum bandwidth $\Delta\lambda$

The bandwidth that includes all wavelengths at which the radiant power is equal to or greater than a specified percentage of the power at the peak-emission wavelength.

NOTE 1 Unless otherwise stated, the specified percentage is 50 %.

NOTE 2 The definition allows peak values lower than the specified percentage to be present within this bandwidth.

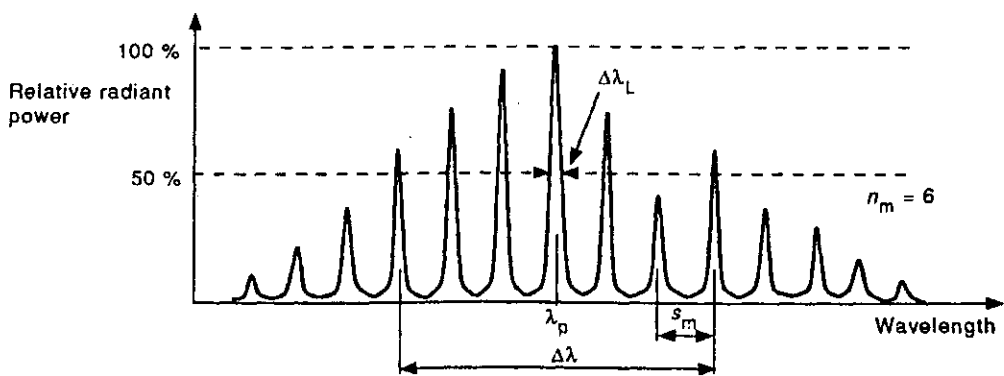


Figure 8 – Spectral characteristics of laser diodes and laser-diode modules

6.2.7.3 Line width $\Delta\lambda_L$

The wavelength interval between those points of an emission line at which the spectral radiant power is half of its maximum value.

6.2.7.4 Central wavelength $\bar{\lambda}$

The weighted average of the mode wavelengths:

$$\bar{\lambda} = \frac{\sum_{i=-\infty}^{i=+\infty} a_i \times \lambda_i}{\sum_{i=-\infty}^{i=+\infty} a_i}$$

where:

λ_i is the wavelength
 a_i is the amplitude

} of the i^{th} spectral line with $i = 0$ for λ_p

6.2.7.5 RMS bandwidth $\Delta\lambda_{\text{rms}}$

The RMS bandwidth is defined by the expression:

$$\Delta\lambda_{\text{rms}} = \sqrt{\frac{\sum_{i=-\infty}^{i=+\infty} a_i \times (\lambda_i - \bar{\lambda})^2}{\sum_{i=-\infty}^{i=+\infty} a_i}}$$

where:

λ_i is the wavelength
 a_i is the amplitude
 $\bar{\lambda}$ is the central wavelength

} of the i^{th} spectral line, with $i = 0$ for λ_p

6.2.7.6 Number of longitudinal modes n_m

The number of longitudinal modes within spectrum bandwidth, including the modes at the band limits.

6.2.7.7 Mode spacing s_m

The difference in wavelength for two neighbouring longitudinal modes.

6.2.7.8 Side-mode suppression ratio SMS

The ratio of:

- the radiant power at the peak-emission wavelength ϕ_{ep} , to
- the radiant power of the next most intense mode ϕ_{es} (see figure 9).

NOTE Side-mode suppression ratio is normally expressed as:

$$SMS = 10 \cdot \log \left(\frac{\phi_{ep}}{\phi_{es}} \right) \quad [\text{dB}]$$

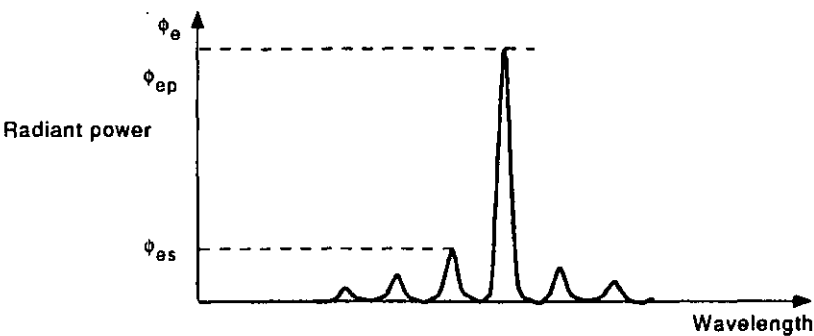


Figure 9 – Side-mode suppression ratio

6.2.7.9 Spectral shift (versus current or temperature) $\Delta\lambda_c$

Under consideration.

6.2.7.10 Input reflection coefficient s_{11}

Under consideration.

6.2.7.11 Radiant power (of a laser chip or submount) ϕ_{e00}

See 6.1 of IEC 62007-1.

6.2.8 Emission source (of a laser diode)

6.2.8.1 Emission source width s_w

On the facet of the laser diode, in the direction of the major axis, the width within which the radiant intensity is larger than or equal to a specified percentage of the maximum value (see figure 10).

NOTE 1 The direction of the major axis is the direction parallel to the PN junction plane.

NOTE 2 Unless otherwise stated, the specified percentage is 50 %.

6.2.8.2 Emission source height s_h

On the facet of the laser diode, in the direction of the minor axis, the height within which the radiant intensity is larger than or equal to a specified percentage of the maximum value (see figure 10).

NOTE 1 The direction of the minor axis is the direction perpendicular to the PN junction plane.

NOTE 2 Unless otherwise stated, the specified percentage is 50 %.

6.2.8.3 Astigmatism d_A

An astigmatism of the emitted radiation that comes from a difference in curvature of the wave front in the directions of the major and minor axis, respectively, whereby usually the centre of the curvature in the direction of the major axis is farther behind the facet than in the other direction.

NOTE 1 The astigmatism can be represented by the curvature $d_A = a - b$ of a convex virtual emission source (see figure 10).

NOTE 2 The value of d_A is calculated from the difference in position of the focusing lens when the focused beam diameter is minimum in each of the two directions.

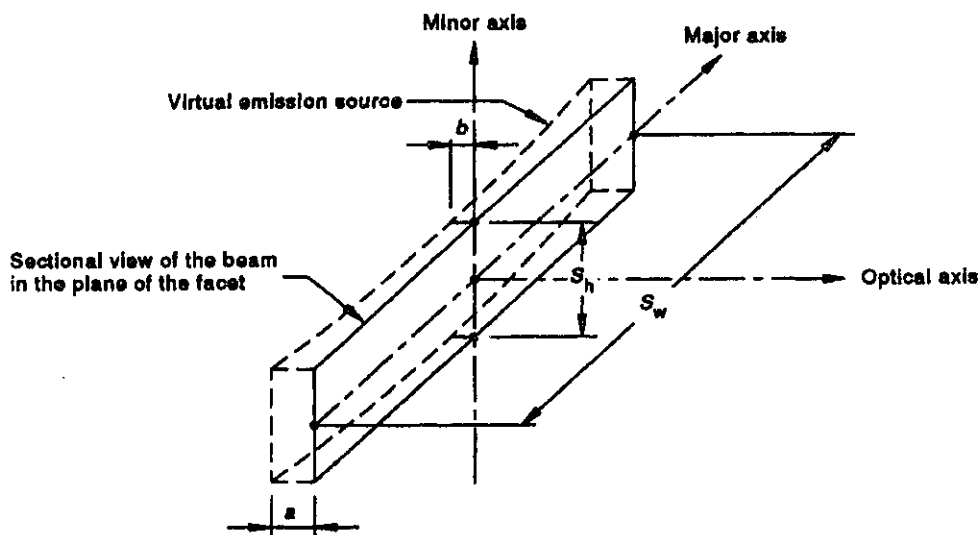


Figure 10 – Emission source of a laser diode

6.2.9 Noise characteristics (of laser diodes)

6.2.9.1 Relative intensity noise RIN

Under consideration.

6.2.9.2 Carrier-to-noise ratio C/N

The quotient of:

- the mean square radiant power at the specified frequency, to
- the mean square radiant power fluctuations normalized to a frequency band of unit width centered on the carrier frequency.

6.2.9.3 K -factor; mode partition noise

Under consideration.

6.2.10 Additional characteristics (of laser-diode modules)

6.2.10.1 Tracking error

Under consideration.

6.3 Photosensitive devices

6.3.1 Output currents (of a photodiode)

NOTE The subscripts D for dark and P for photo are still under consideration.

6.3.1.1 Reverse current (under optical radiation) $I_{R(H)}$ or $I_{R(e)}$, I_R

The total reverse current when the photodiode is exposed to incident optical radiation.

6.3.1.2 Dark current $I_{R(D)}$

The reverse current in the absence of incident optical radiation.

6.3.1.3 Photocurrent I_P

That part of the reverse current that is caused by incident optical radiation:

$$I_P = I_{R(H)} - I_{R(D)}$$

6.3.2 Output currents (of a phototransistor)

6.3.2.1 Collector current (under optical radiation) $I_{C(H)}$ or $I_{C(e)}$, I_C

The total collector current when the phototransistor is exposed to incident optical radiation.

6.3.2.2 Collector-emitter dark current I_{CEO}

The collector current in the absence of incident optical radiation.

6.3.3 Sensitivity

6.3.3.1 (Diode) sensitivity S_D , S (of a photodiode)

The quotient of

- the photocurrent I_P , by
- the irradiance E_e (or illuminance E_v) at the optical port of the photodiode.

$$S_D = \frac{I_P}{E_e} \text{ or } S_D = \frac{I_P}{E_v}$$

NOTE If no ambiguity is likely to occur, the shorter term and letter symbol may be used.

6.3.3.2 (Fibre-input) sensitivity S_{FD} , S (of a photodiode irradiated [illuminated] from the front end of an optical fibre) (see figure 11)

The quotient of

- the photocurrent I_P , by
- the radiant power ϕ_e (or luminous flux ϕ_v) emitted from the optical fibre, for specified values of the radial displacement r and the distance z of the front end of the optical fibre, relative to the optical port of the photodiode.

$$S_{FD} = \frac{I_P}{\phi_e} \text{ or } S_{FD} = \frac{I_P}{\phi_v}$$

NOTE 1 If no ambiguity is likely to occur, the shorter term and letter symbol may be used.

NOTE 2 In specifications, usually curves are given showing S_{FD} as a function of r and z .

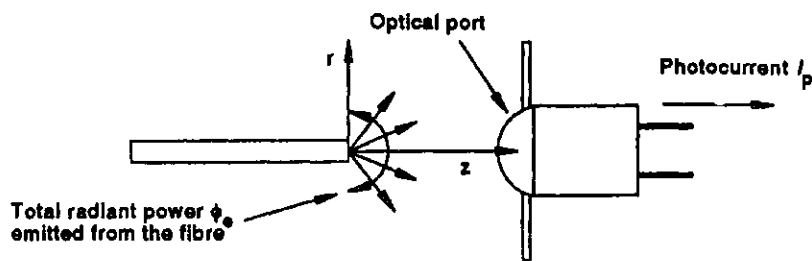


Figure 11 – Fibre-input sensitivity S_{FD}

6.3.4 Cut-off frequency (of a photodiode)

6.3.4.1 Small-signal cut-off frequency f_{cd} , f_c

The frequency at which, for constant small signal modulation depth of the input radiant power, the demodulated signal power has decreased to 1/2 of its low-frequency value.

NOTE When, for the measurement of f_c , the photocurrent of the photodiode is observed, a 1-to-2 decrease in radiant power corresponds to a 1-to-2 decrease in photocurrent. Therefore, when the latter is measured as a voltage drop across a load resistance, the criterion of a 1-to-2 decrease applies also to the voltage, provided the load resistance is small compared with the output resistance of the photodiode.

6.3.4.2 Large-signal cut-off frequency f_{cL} , f_c

The frequency at which, for constant large signal modulation depth of the input radiant power, the demodulated signal power has decreased to 1/2 of its low-frequency value.

NOTE The note to 6.3.4.1 applies accordingly.

6.3.5 Spatial sensitivity diagram and related characteristics (of photosensitive devices)

6.3.5.1 Sensitivity diagram

A diagram that characterizes the distribution of sensitivity:

$$S = f(\theta) \text{ (see figures 12a and 12b)}$$

NOTE 1 Unless otherwise stated, the distribution of sensitivity should be specified in a plane. This plane includes the mechanical axis z.

NOTE 2 If the sensitivity pattern has a rotational symmetry to the z axis, the sensitivity diagram shall be specified for one plane only.

NOTE 3 If the sensitivity pattern has no rotational symmetry to the z axis, sensitivity diagrams for various angles θ shall be specified. Then the x, y and z directions shall be defined by a drawing in the detail specification.

6.3.5.2 Half-sensitivity angle $\theta_{s/2}$

In a sensitivity diagram, the angle within which the sensitivity is greater than or equal to half of the maximum sensitivity (see figure 12b).

6.3.5.3 Misalignment angle $\Delta\theta$

In a sensitivity diagram, the angle between the direction for maximum sensitivity (optical axis) and the mechanical axis z (see figure 12b).

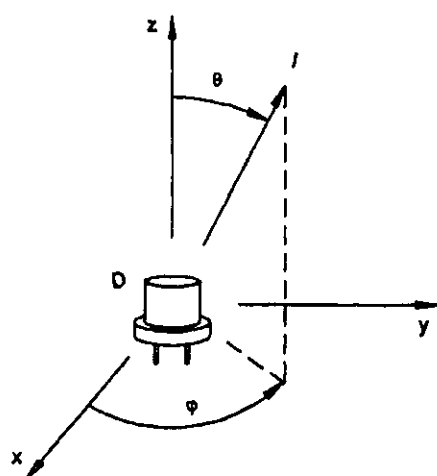


Figure 12a

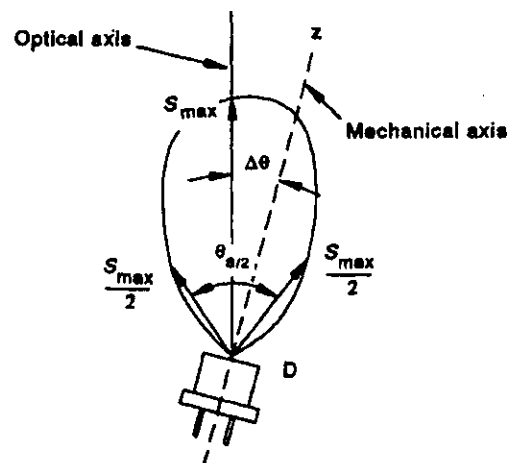


Figure 12b

Figure 12 – Sensitivity diagram and related characteristics

6.3.6 Spectral characteristics (of photosensitive devices)

6.3.6.1 Peak-sensitivity wavelength λ_p

The wavelength at which the spectral sensitivity is a maximum.

6.3.7 Multiplication factor M (of an avalanche photodiode)

The ratio of:

- the photocurrent under a condition at which carrier multiplication takes place (I_{R1} at V_{R1}), to
- the photocurrent under a condition at which no carrier multiplication takes place (I_{R2} at V_{R2}):

$$M = \frac{I_{R1}}{I_{R2}} \text{ (see figure 13)}$$

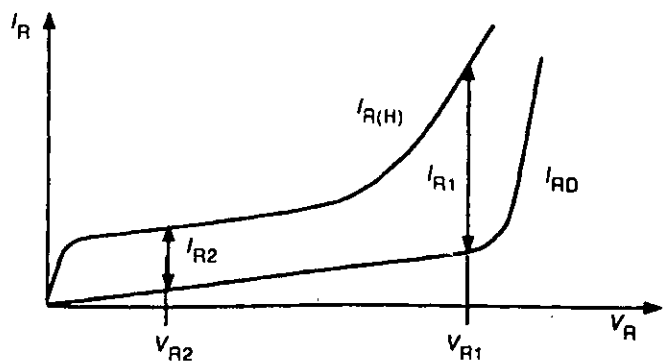


Figure 13 – Multiplication factor of an avalanche diode

6.3.8 Excess noise factor (of an avalanche photodiode)

Under consideration.

6.4 Photocouplers, optocouplers

6.4.1 Current transfer ratio

6.4.1.1 Static value of the (forward) current transfer ratio $h_{F(ctr)}$, h_F

The ratio of the d.c. output current to the d.c. input current, the output voltage being held constant.

NOTE The abbreviation CTR(d.c.) is sometimes used instead of a symbol.

6.4.1.2 Small-signal short-circuit (forward) current transfer ratio $h_{f(ctr)}$, h_f

The ratio of the a.c. output current to the a.c. input current, the output being short-circuited to a.c.

NOTE The abbreviation CTR(a.c.) is sometimes used instead of a symbol.

6.4.2 Cut-off frequency f_{ctr}

The frequency at which the modulus of the small-signal current transfer ratio has decreased to $1/\sqrt{2}$ of its low-frequency value.

6.4.3 Input-to-output capacitance C_{IO}

The total capacitance between all input terminals connected together and all output terminals connected together.

6.4.4 Isolation resistance R_{IO}

The resistance between all input terminals connected together and all output terminals connected together.

6.4.5 Isolation voltage

The voltage between any specified input terminal and any specified output terminal.

6.4.5.1 DC isolation voltage V_{IO}

The value of the constant isolation voltage.

6.4.5.2 Repetitive peak isolation voltage V_{IORM}

The highest instantaneous value of the isolation voltage including all repetitive transient voltages, but excluding all non-repetitive transient voltages.

NOTE A repetitive transient voltage is usually a function of the circuit. A non-repetitive transient voltage is usually due to an external cause and it is assumed that its effect has completely disappeared before the next non-repetitive voltage transient arrives.

6.4.5.3 Surge isolation voltage V_{IOSM}

The highest instantaneous value of an isolation voltage pulse of short time duration and of specified waveshape.

6.4.6 Photocoupler providing protection against electrical shock

A photocoupler designed to maintain protection against electrical shock after it has been subjected to operating conditions (safety ratings) that exceed the specified ratings (limiting values) for normal operation.

6.4.7 Safety ratings (of a photocoupler for reinforced isolation)

Electrical, thermal, and mechanical operating conditions that exceed the specified ratings (limiting values) for normal operation, and to which the specified safety requirements refer.

6.4.8 Electrical safety requirements (of a photocoupler for reinforced isolation)

Electrical requirements that have to be met and maintained after the photocoupler has been subjected to the specified safety ratings to ensure protection against electrical shock.

NOTE The photocoupler may become permanently inoperative when safety ratings are applied.

6.4.9 Partial discharge (pd)

Localized electrical discharge which occurs in the insulation between input and output terminals of the photocoupler.

6.4.10 Apparent charge q_{pd} , q

Electrical discharge caused by a partial discharge in the photocoupler.

6.4.11 Threshold apparent charge $q_{pd(TH)}$, q_{TH}

A specified value of apparent charge that is as small as technically feasible and to which measured values of the partial-discharge inception voltage or extinction voltage, respectively, refer.

NOTE 1 A threshold apparent charge of 5 pC was found to be a practicable criterion for photocouplers. Smaller values are desirable but are not viable at this time.

NOTE 2 In actual tests, this criterion applies to the apparent charge pulse with the maximum value.

NOTE 3 The term "specified discharge magnitude" (see 1.3.18.2 of IEC 60664-1) is synonymous with "threshold apparent charge".

6.4.12 Test voltages (for the partial-discharge test of a photocoupler)

See figure 14. All voltages used are a.c. peak voltages.

6.4.12.1 Test voltage $V_{pd(t)}$, V_t

The voltage applied during the test period between the input terminals (connected together) and the output terminals (connected together), respectively, of the specimen under test.

Partial discharge test voltage: $V_{pd(t)}$

The isolation voltage applied during the partial discharge test period.

NOTE 1 Specified values of this voltage may be expressed as a multiple of the specified value of the rated isolation voltage or rated repetitive peak isolation voltage: $V_{pd(m)} = F \times V_{IOWM}$ or $V_{pd(m)} = F \times V_{IORM}$, whichever is higher. Refer to 6.4.12.2 c), multiplying factor.

NOTE 2 Test voltage, where the apparent charge has to be equal or less than the specified value.

6.4.12.2 Initial test voltage $V_{pd(i)l}$, V_{ini}

The test voltage applied during the initial test time t_{ini} .

NOTE 1 The initial test voltage is higher than or equal to the test voltage in the second part of the test period in which partial discharge characteristics are measured; see 6.4.12.3.

NOTE 2 For method a), the specified value for the initial test voltage is equal to the specified limiting value of the rated impulse isolation voltage V_{IOTM} .

NOTE 3 For method b), the specified value for the initial test voltage (isolation voltage) is equal to or lower than the specified limiting value of the rated impulse isolation voltage V_{IOTM} .

a) Initial voltage: $V_{pd(i)l,a}$; $V_{ini,a}$ (see table 1 of IEC 60664-1 for minimum voltages, interpolation is possible).

The value of the voltage applied at the beginning of the measurement, for a specified time t_{ini} , which is intended to simulate the occurrence of a transient overvoltage.

b) Initial test voltage: $V_{pd(i)l,b}$; $V_{ini,b}$

The isolation test voltage applied between the short-circuited input and the short-circuited output terminals at routine test (method b)). A withstand voltage equal to the manufacturer's rating with a maximum of V_{IOTM} .

NOTE The equivalent r.m.s. value of an a.c. test voltage may also be used.

c) Multiplying factor: F

At routine test stage: $F = 1,875$

At sample test stage and after life tests, subgroup 1: $F = 1,6$

After life tests, subgroups 2 and 3: $F = 1,2$

NOTE When the test result using the above F factors is certainly affected by testability on, for example, the device package size, package leads or the test system, the following F factors can be chosen instead by manufacturer's decision: $F = 1,6$, $F = 1,2$ and $F = 1,0$ respectively.

6.4.12.3 Apparent charge measuring voltage $V_{pd(m)}$, V_m

The test voltage for which apparent charge is measured.

6.4.13 Partial-discharge inception voltage $V_{pd(l)}$, V_l

The lowest peak value of an a.c. test voltage at which the apparent charge is greater than the specified threshold apparent charge, if the test voltage is increased from a lower value where no partial discharge occurs.

NOTE The equivalent r.m.s. value of an a.c. test voltage may also be used.

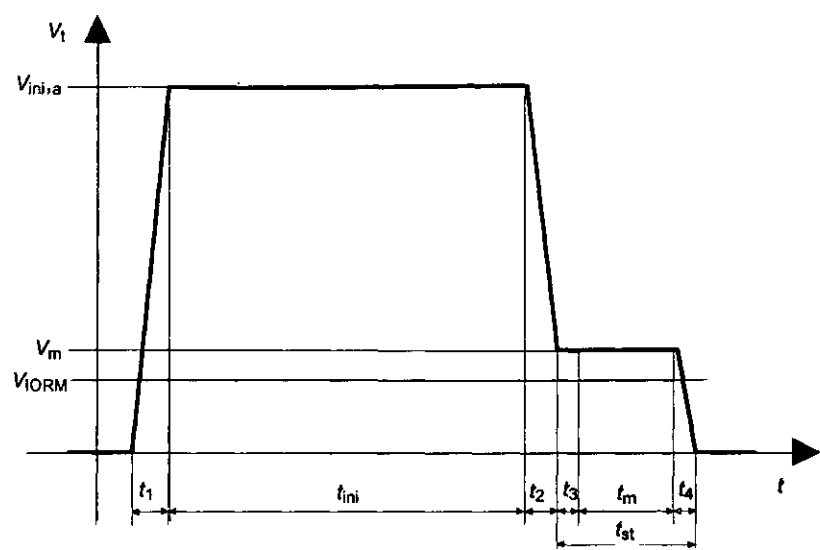
6.4.14 Partial-discharge extinction voltage $V_{pd(e)}$, V_e

The lowest peak value of an a.c. test voltage at which the apparent charge is smaller than the specified threshold apparent charge, if the test voltage is reduced from a higher value where such discharge occurs.

NOTE The equivalent r.m.s. value of an a.c. test voltage may also be used.

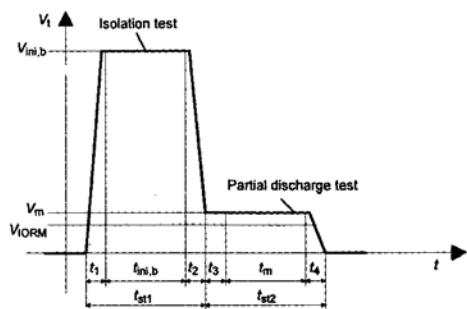
6.4.15 Time intervals of the test voltage

See the terms and letter symbols indicated in figures 14a and 14b

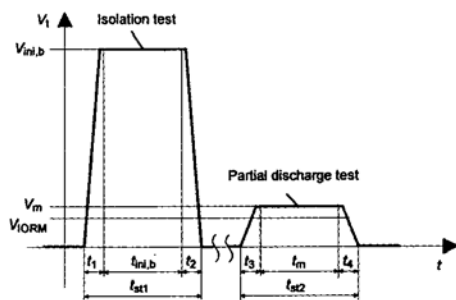


- t_{ini} Initial time (method a) only
- t_{st} (Partial-discharge) stress time
- t_m (Partial-discharge) measuring time
- t_1, t_2, t_3, t_4 Settling times

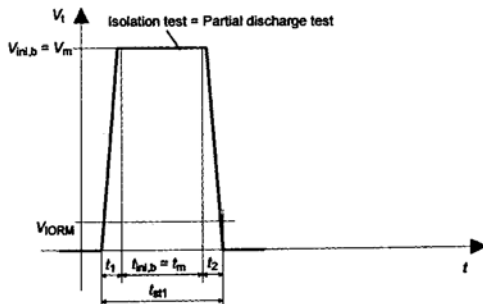
Figure 14a – Time intervals for method a)



Method b1)



Method b2)



Method b3)

$t_{ini,b}$ Isolation test time (method b) only
 t_{st2} (Partial-discharge) stress time
 t_1, t_2, t_3, t_4 Settling times
 t_{st1} Isolation test stress time (method b) only
 t_m (Partial-discharge) measuring time

Figure 14b – Time intervals for method b)

Figure 14 – Time intervals of the test voltage

6.4.16 Isolation voltages and isolation test voltages for photocouplers providing protection against electrical shock

6.4.16.1 Maximum rated isolation voltage: V_{IO}

The maximum voltage between all input terminals (connected together) and all output terminals (connected together), respectively.

a) Maximum rated isolation working voltage: V_{IOWM}

A r.m.s. value of withstand voltage assigned by the manufacturer of the photocoupler, characterizing the specified (long term) withstand capability of its isolation.

NOTE The r.m.s. voltage includes equivalent d.c. voltage.

b) Maximum rated repetitive peak isolation voltage: V_{IORM}

A repetitive peak value of withstand voltage assigned by the manufacturer of the photocoupler, characterizing the specified withstand capability of its isolation against repetitive peak voltages.

NOTE This is the peak value of the waveform indicated in a) above, if the waveform is sinusoidal.

c) Maximum rated isolation transient voltage: V_{IOTM}

A value of impulse withstand voltage assigned by the manufacturer of the photocoupler, characterizing the specified withstand capability of its isolation against transient overvoltages.

6.4.17 Repetitive peak voltage

6.4.17.1 Repetitive peak off-state voltage

maximum applicable repetitive peak forward voltage between anode and cathode in off state under specified gate conditions.

NOTE The repetitive voltage has a slew rate of less than the specified critical rate of rise of off-state voltage (dv/dt).

6.4.17.2 Repetitive peak reverse voltage

maximum applicable repetitive peak reverse voltage between anode and cathode under specified gate conditions.

6.4.17.3 RMS on-state current

maximum applicable root-mean-square forward current between anode and cathode in on state under specified gate conditions.

6.4.18 Photocouplers with phototriac output

6.4.18.1 Peak off-state current (I_{DRM})

Forward leakage current between the off-state output terminals under specified conditions.

6.4.18.2 Peak on-state voltage (V_{TM})

Peak forward voltage between on-state output terminals under specified conditions.

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6.4.18.3 DC off-state current (I_{BD})

Forward leakage current between off-state output terminals under specified conditions

6.4.18.4 DC on-state voltage (V_T)

The d.c. forward voltage between on-state output terminals under specified conditions, when the specified forward current is applied between on-state output terminals.

6.4.18.5 Holding current (I_H)

The minimum on-state current in output to maintain the on-state under specified conditions.

6.4.18.6 Critical rate of rise of off-state voltage (dV/dt)

The rate of rise of off-state voltage just before the transition from off-state to on-state under the specified operating conditions.

6.4.18.7 Trigger input current (I_{FT})

The minimum input forward current to switch from off-state to on-state in output under specified conditions.

Annex A
(informative)

Cross references index

IEC 60747-5	New clause number	Title	Old clause number	Document or publication
60747-5-1	3	Physical concepts	1	60747-5, Chapter II
	4	Types of devices	2	60747-5, Chapter II
	5	General terms	3	60747-5, Chapter II
	6	Terms related to ratings and characteristics	4	47C/173/FDIS
60747-5-2		Essential ratings and characteristics		60747-5, Chapter III
	3	Light-emitting diodes	Section one	47C/173/FDIS
	4	Infrared emitting diodes	Section two	
	5	Photodiodes	Section three	
	6	Phototransistors	Section four	
	7	Photocouplers/optocouplers	Section five	
	8	Photocouplers providing protection against electric shock		
60747-5-3	9	Laser diodes	Section six	60747-5, Chapter III
		Measuring methods		60747-5, Chapter IV
	3	Photoemitters	1	
	4	Photosensitive devices	2	
	5	Photocouplers	3	

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IEC 62007	New clause number	Title	Old clause number	Document or publication
62007-1	3	Terms and definitions	3.1	60747-5, Chapter II 86/113/FDIS
62007-1		Essential ratings and characteristics		60747-5, Chapter III
	4	Light emitting diodes and infrared emitting diodes	Section seven	
	5	Laser modules with pigtails	Section eight	
	6	Pin photodiodes	Section nine	
	7	Avalanche photodiodes with or without pigtails	Section ten	
	8	PIN-FET modules		86/113/FDIS
	9	Laser diode modules for pumping an optical fibre amplifier		86/113/FDIS
	10	Laser diode modules for fibre optic analogue transmission		86/113/FDIS
	11	LED arrays		86/113/FDIS
	12	Optical modulators for digital fibre optic applications		86/113/FDIS
62007-2		Measuring methods		60747-5, Chapter IV
	3	Photoemitters	1	
	4	Photosensitive devices	2	

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Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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